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Development of Ni-Cr-Al Alloys
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Development of Ni-Cr-Al Alloys
for
High Temperature Tubing Applications

Abstract

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Tensile test results are presented for as received strip material aged without prior solution anneal and strip material after heliarc welding or brazing with a nickel-silicon-boron material. The welded samples were processed in two groups. One group of samples was aged prior to welding, while the second group was aged after welding.

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INTRODUCTION

The Ni-Cr-Al alloy systems offer considerable promise for the development of elevated temperature materials with high strength. In the high Cr-high Al compositions, they may find use as bearings and tools and in the lower Cr-Al range as oxidation resistant sheet. During the course of this program, the Ni-Cr-Al alloy systems will be studied to develop an alloy with high strength, good formability and brazing characteristics for high temperature tubing applications.

RESULTS

Samples of alloy HM32 were heliarc welded. One set of samples was solution treated prior to welding and then aged 20 hours at 1400° F. Tensile tests were conducted at room temperature to 1500° F. The results, shown in Table I, are comparable to that obtained with solution treated and aged strip (Second Quarterly Progress Report). A second set of samples was solution treated and aged 20 hours at 1400° F prior to welding and then tensile tested at room temperature to 1500° F. Although the properties in this case, shown in Table II, were lower than when the samples were aged after welding, the results indicate that repair type welds can be made on structures without significant effect on properties.

Of three brazing alloys investigated for compatibility with Ni-Cr-Al alloys, only AMS4778, a nickel-silicon-boron material, effectively wet the nickel-chromium-aluminum alloys. Further heat treatment conducted with this braze and HM32, the alloy selected for tubing, did not result in any detrimental effects as examined by metallography or hardness measurements.

Additional samples of alloy HM32 were brazed with AMS4778 for 30 minutes in hydrogen at 1975° F. The brazed samples were then aged 2 hours at 1400° F and tensile tested at room temperature to 1500° F. The results, shown in Table III, indicate lower strength and ductility as compared to solution treated and aged material (Second Quarterly Progress Report). All failures were in the area of the braze and indicated brittleness. The failures are related to the strength of the braze material rather than a weakness of HM32 from interaction with the braze.

On the basis of aging studies conducted with the as received 1/16" strip (Revised First Quarterly Progress Report), samples were prepared for tensile testing of aged as received strip without a prior solution anneal. Alloy HM31 was aged for 2 hours at 1200° F and alloys HM30 and HM32 were aged at 1400° F for 10 hours and 2 hours respectively. The results of the tensile tests conducted at room temperature to

2000° F are shown in Table IV. In general, the alloys had higher tensile strengths and lower ductilities up to 1500° F as compared to the case when the strip material is solution treated prior to aging. Above 1500° F, there was no significant difference in alloy properties when the strip is aged with or without a prior solution anneal.

Alloy HM32 has previously been selected for the preparation of tubing. Additional material has been vacuum melted and processed through preliminary breakdown procedures. Experiments are now in progress towards producing tubing.

FUTURE WORK

The major effort during the next report period will be devoted toward the preparation of extruded tubing of alloy HM32.

TABLE I. Tensile Properties of Welded HM32 Strip Aged for 20 Hours at 1400° F after welding

<u>Temperature</u>	<u>U.T.S. (psi)</u>	<u>0.2% Y.S. (psi)</u>	<u>%El.</u>	<u>%R.A.</u>
Room Temp	143,000	73,400	13	17
900° F	121,000	61,500	12	5
1200° F	98,500	52,400	8	16
1500° F	42,700	22,600	26	21

TABLE II. Tensile Properties of HM32 Strip Welded after Aging for 20 Hours at 1400° F.

<u>Temperature</u>	<u>U.T.S. (psi)</u>	<u>0.2% Y.S. (psi)</u>	<u>%El.</u>	<u>%R.A.</u>
Room Temp	93,600	41,200	31	49
900° F	80,600	40,000	36	62
1200° F	66,500	30,800	33	34
1500° F	30,300	22,600	43	31

TABLE III. Tensile Properties of Brazed HM32 Strip Aged for 2 Hours at 1400° F after Brazing.

<u>Temperature</u>	<u>U.T.S. (psi)</u>	<u>0.2% Y.S. (psi)</u>	<u>%El.</u>	<u>%R.A.</u>
Room Temp	100,000	65,500	9	6
900° F	70,800	51,200	5	4
1200° F	60,000	40,000	3	7
1500° F	33,000	31,000	5	2

TABLE IV

Tensile Test Results

Specimens Machined from 1/16" Strip

	HM90*		EL	R.A.	HM11*		EL	R.A.	HM12*		EL	R.A.	0.2% Y.S.	0.2% Y.S.
	0.2% Y.S.	UTS			0.2% Y.S.	UTS			0.2% Y.S.	UTS				
As Recd.	-	307,500	4%	3%	-	214,500**	-	-	-	177,500	-	-	-	-
1000° F	-	171,000	5%	8%	-	132,000**	-	-	-	142,000	-	-	-	-
1200° F	-	129,000	9%	6%	-	152,700	6%	1%	-	160,000	-	-	-	-
1400° F	24,400	48,700	17%	12%	52,100	50,000	18%	12%	15,000	40,000	15,000	12%	15,000	15,000
1600° F	3,000	17,100	54%	36%	29,000	48,700	17%	21%	4,500	35,000	4,500	21%	4,500	4,500
1800° F	2,100	5,200	68%	33%	2,200	4,400	150%	61%	3,300	3,000	3,300	61%	3,300	3,300

As received strip aged 10 hours at 1400° F

As received strip aged 2 hours at 1200° F

As received strip aged 2 hours at 1000° F

*Specimen broke in holder